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PRUNING
CITRUS TREES
IN THE
SOUTHWEST



PROGRESSIVE GROWERS of both citrus and deciduous tree fruits are coming to realize more and more that pruning is one of the most important operations to which they have to give attention in connection with the maintenance of their orchards; that, wisely performed, it may be made to contribute materially to the success of their enterprise; but if done injudiciously it may largely defeat not only its own ends, but the ends for which all other operations in the orchard are performed.

It is only the grower who is able the most accurately to interpret in terms of pruning the appearance and behavior of his trees who can judge best as to the type and extent of pruning which will be most beneficial in the case of a particular tree.

Constructive pruning consists of much more than the indiscriminate removal of limbs which seem to be in the way. Pruning is a physiological operation which may promote or interfere with the normal and efficient functioning of the different parts of the tree, including its root system. The grower should remember that the raw food material taken up by the roots is elaborated in the foliage, and that any pruning which greatly disturbs the relationship of the leaf area to the food supply and the requirements of other parts of the tree is likely to result adversely.

The information presented in this bulletin is based largely on careful observations made of citrus trees in California in connection with the investigations in fruit improvement through bud selection. It has been brought out in these studies that the details of pruning of individual trees are very largely influenced by the character of the buds used in propagation. These studies have established certain principles which may be enumerated as follows:

Little pruning is necessary in the case of trees grown from buds taken from the fruit wood of superior parent trees.

Severe pruning of normal citrus trees is unnecessary and injurious.

Early fruit-bearing growth on young trees should not be cut off.

Pruning should be guided by the behavior of pruned as compared with unpruned trees, as shown by their performance records.

PRUNING CITRUS TREES IN THE SOUTHWEST.

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INTRODUCTION.

THE CITRUS GROWERS of California and Arizona became keenly interested in the work of pruning following the freezes of the winter of 1912-13. Previous to that time there had been wide differences of opinion with regard to the desirability of pruning healthy full-bearing trees, and the methods practiced by those who believed pruning to be a necessary part of citrus culture varied greatly in degree, time of operation, and other important factors. This was largely due to the absence of definite knowledge of the effects on crop production resulting from any specific system of pruning.

Frost injury to citrus trees during the 1912-13 freezes stimulated a widespread interest in pruning during subsequent seasons, and many crews of experienced pruners were organized, representing in their methods of work wide variations from previous practices. In order to determine the effect of these practices upon fruit production, the writer and his associates carried on a series of comparative pruning studies with full-bearing orange, lemon, and grapefruit trees located in a large commercial orchard in a typical citrus district of southern California. The results of these studies of the behavior of pruned and unpruned full-bearing citrus trees show that under the conditions in the orchard where this investigation was conducted, heavy pruning was detrimental to the yield and commercial value of the crops borne by normal full-bearing trees of orange, lemon,

and grapefruit varieties about in proportion to the severity of pruning. Not only were the yields reduced by pruning, but there was no apparent improvement in the commercial sizes or grades of the fruit borne by severely pruned as compared with those from unpruned trees. The results of this investigation demonstrated the necessity for definite information based on individual tree-performance records as to the behavior of pruned and unpruned trees under different conditions as a basis for establishing safe and efficient methods of pruning. This bulletin briefly discusses some of the underlying principles of pruning and training citrus trees which have developed as a result of these experimental studies and from observations of the results of commercial pruning practices.

OBJECTS OF PRUNING.

The necessity for pruning citrus trees begins in the nursery and continues during their entire lifetime. The objects of pruning include (1) heading the young nursery trees; (2) training the main limbs in order to form the strongest possible framework; (3) removal of objectionable branches, such as crossed limbs, suckers, and injured or decadent growth; (4) thinning the fruit-bearing wood to admit light and stimulate the rate of growth of the fruits or to influence their size; (5) control of the arrangement and distribution of the vegetative growth in order to have well-balanced tops and accessible fruit; (6) treatment of limbs or trees attacked by fungous diseases or insect enemies; and (7) renewal of old and decadent trees.

METHODS OF PRUNING.

From time to time various pruners have introduced rather definite methods of pruning in California and Arizona citrus orchards which differed mainly in the quantity and kind of growth removed, in the shape of tree tops left after pruning, and in the plan of arrangement of the framework or other similar characteristics. For one reason or another most of the radical systems have been largely abandoned in commercial orchard pruning. The good points, if any, of each system as brought out by experience have been preserved and the others discarded. The method which has evolved as a result of experience and observation of the behavior of trees pruned according to individual practices may be termed the California method. A brief description of this method follows.

HEADING YOUNG TREES.

The principles of heading of young orange, lemon, and grapefruit trees are practically the same.

Heading the young citrus trees is usually done in the nursery, and usually 28 to 30 inches above the bud union. Low heading was formerly popular because it was thought that this arrangement would result in developing low tree tops with easily accessible fruit. As the fruits borne by the lower branches of such trees are frequently injured by contact with the ground or with implements of culture, the low-heading practice has been generally abandoned. Fol-

lowing the extremely low-heading method, extremely high heading was practiced by some propagators. This practice also fell into disrepute on account of certain disadvantages which became evident with experience, including greater cost of picking and increased expense of fumigation and other tree treatments. Both of those extremes have been largely abandoned, and during the past few years young trees have been generally headed so as to avoid the difficulties which result from trees having extremely low or very high heads.

Heading is accomplished by cutting off the tops of young trees at the height at which it is desired to form the head, as shown in Figure 1. It is advisable to use a measuring stick in order to make all of the cuts at a uniform height above the ground.

ARRANGEMENT OF THE MAIN BRANCHES.

After heading, or topping as it is frequently called, numerous branches develop on the young tree trunks back of the cuts. Formerly it was the custom to cut or break off all of these growths except three to five immediately back of each cut. This plan resulted in developing a head consisting of several main branches arising at or very near the same point. This form of head has been found to be somewhat undesirable on account of the tendency of the main branches to split off under the strain of heavy crops of fruit. A better arrangement of the branches intended for the main limbs is to space them several inches apart, so that they will arise at different points along the tree trunks. From three to five branches should be left on each tree for this purpose, spaced spirally around the trunk in order to develop into a well-balanced and strong framework for the future tree tops, as shown in Figure 2. All growth other than that intended for the framework limbs should be carefully removed during the first season after heading, as shown in Figure 3.

One style of forming the framework of trees is developed in the following manner: As soon as the young main limbs make a period of growth they are cut or pinched back. Following this pruning additional branches will develop back of the cuts on each limb. These growths are usually thinned to two or three located on the outside of the limbs, as shown in Figure 4. The second season each of the growths of the preceding season should be cut back, and the resulting branches thinned as before. In this way a bowl-shaped framework will be developed, which under certain circumstances is desired by many citrus growers.

Another framework arrangement preferred by some citrus growers has several points of apparent advantage. This arrangement is secured by allowing the original main limbs to grow uninterrupted, taking care to thin out interfering growth. By following this plan the final framework will consist of from three to five upright growing limbs. Such trees are usually referred to as having a vase shape in contrast to those with the more spreading and open bowl shape. A 6-year-old Lisbon lemon trained to the vase shape is shown in Figure 5, and the interior framework of this same tree is shown in Figure 6. Among the advantages claimed for the vase-shaped trees are greater strength of framework, better protection to the



FIG. 1.—Topping young citrus trees in the nursery for the purpose of developing the heads. A measuring stick is used in this work, so as to make the cuts at a uniform height from the ground. The cuts are usually made with short-handled shears.

fruits from sunburn or other exposure, and longer life. It is rather significant that the trees in several of the oldest and best citrus orchards in California have been trained to the vase or upright shape. An apparent disadvantage of this method lies in the greater expense of picking the fruit from the taller vase-shaped trees as compared with the cost of harvesting the lower growing bowl-shaped trees. Another possible disadvantage of the vase-shaped trees, as contrasted with the lower growing bowl-shaped trees, lies in the in-



FIG. 2.—Young nursery trees after pruning following the second season of growth. A more desirable practice would have been to space the branches farther apart.

creased cost of fumigating, spraying, pruning, and other tree treatments.

Decision as to the arrangement of the framework of the trees will depend largely upon local conditions, including variety, probable exposure to wind and sunburn damage, cost of labor in picking, expense of disease and pest control, and other factors of tree care. With the inherently fruitful strains of trees now commonly grown in the Southwest the vase-shaped system of framework arrangement is usually considered superior to the bowl shape.

CARE OF THE EARLY FRUIT-BEARING GROWTH.

Up to seven or eight years ago there was a general tendency to prune off the early fruit-bearing growth from young citrus trees. The theory on which this practice was based was that early production of fruit was detrimental to the development of the young

trees. Ten years ago a considerable acreage of citrus trees grown from carefully selected buds secured from heavy-bearing parent trees producing uniformly good fruits was planted in several locations in different citrus districts of southern California. In order to obtain an early measure of the productiveness of these progeny trees and definite evidence as to the strain characteristics of the fruits borne by them, none of the early fruit wood was removed. The



FIG. 3.—Young citrus trees similar to those shown in Figure 2 after baling and ready for planting, showing the arrangement of the framework branches, which should have been spaced farther apart, and the method of pruning preliminary to transplanting.

only pruning practiced with these trees was to control the arrangement of framework limbs. The trees began to bear commercial quantities of particularly uniform and desirable fruits during the second year after planting in the orchards. A typical example of one of these trees is shown in Figure 7. Subsequent tree-performance records and observations of these and comparable trees pruned in the ordinary way have shown that early fruiting of the unpruned trees has had no apparent detrimental influence on the growth or behavior of the trees. On the contrary, the unpruned young trees

made a better growth and developed into better trees from all standpoints than those where the early fruit wood was removed. This conclusion has been repeatedly confirmed during recent years in many large commercial citrus plantings. These facts are of great importance for a number of reasons, including the saving of the cost of pruning, the production of a valuable early crop, and the better growth conditions of the unpruned or lightly pruned as compared with the more severely pruned young trees. Experience of recent years both in an experimental as well as a commercial way shows that the early fruit-bearing growth of young citrus trees should not be pruned off.

With trees grown from carefully selected buds secured from superior parent trees there is likely to be very little objectionable growth to be removed. With ordinary trees, particularly those producing considerable sucker growth, it is probable that rather frequent thinning and removal of such growth will be necessary. A 3-year-old Eureka lemon tree propagated from a parent tree of one of the vegetative strains is shown in Figure 8. Comparing this tree with the one shown in Figure 7 it is seen to be producing a dense growth of nonbearing branches, which require pruning and thinning, rather than the fruiting wood which is to be desired.



FIG. 4.—Young citrus tree six months after planting, showing the arrangement of branches, form of head, and habit of growth.

PRUNING FULL-BEARING ORANGE AND GRAPEFRUIT TREES.

The term "full-bearing" is here used to define citrus trees during that period following early fruiting and before production is interfered with by reason of old age, decadence, and related causes. The methods of pruning full-bearing orange and grapefruit trees are so nearly alike that their care in this respect may be considered under one head. The pruning of full-bearing lemon trees differs in some

particulars from that of orange and grapefruit trees and will be described separately.

In the experimental studies of the behavior of unpruned healthy full-bearing orange and grapefruit trees as compared with those pruned with different degrees of severity, as shown by the quantity of growth removed and by somewhat different commercial pruning systems, it was found that the unpruned trees consistently produced more fruit during the 5-year period of investigation. A typical

unpruned Washington Navel orange tree in this investigation is shown in Figure 9 and a severely pruned tree in Figure 10.

The unpruned trees produced larger crops, and the fruits were practically the same in size and grade as those borne by the pruned trees.

These results were contrary to theories commonly accepted at the time this study was carried on. Subsequent experimental study and extensive observations of results of commercial pruning have confirmed the conclusions reached as a result of these investigations.

After considering all available experimental evidence and commercial results, it can be said that little pruning should be done in healthy and



FIG. 5.—A 6-year-old Lisbon lemon tree trained to the vase shape. The interior framework of this tree is shown in Figure 6.

normal full-bearing orange and grapefruit trees. It seems advisable to remove dead or decadent growth which might bruise, scratch, or otherwise injure the fruits. Suckers or other objectionable branches should be removed. With inherently productive trees there are very few such growths.

PRUNING FULL-BEARING LEMON TREES.

On account of their more abundant and vigorous vegetative growth it seems probable that full-bearing lemon trees need more regular pruning than orange and grapefruit trees. From the fact of their

lower resistance to frost the season of pruning is probably more vital in the case of lemon than of orange and grapefruit trees.

Cutting back the limbs of bowl-shaped lemon trees or thinning the larger growths of vase-shaped trees should be done during late winter or spring after danger of injuries from low temperatures has passed. This pruning will usually be followed by the development of numerous branches, especially in vegetative strains, which should be thinned or cut back during the summer months, preferably not later than the first of August. In this way any growths stimulated by summer pruning will reach sufficient maturity, or "harden up" as this condition is commonly called, before danger of frost injury.

Heavy pruning of healthy normal lemon trees has been found to be as injurious as the severe pruning of orange and grapefruit trees. Sometimes this practice seems advisable in order to accelerate the rate of growth of the fruits so as to secure merchantable sizes for particular market seasons or for other reasons. The season of fruiting of lemons can be appreciably influenced

by pruning through hastening the rate of growth, but the most effective means for securing this result is by withholding or applying irrigation water at certain periods in order to hold back or stimulate growth and blossoming.

All available information on this subject shows that the pruning of normal full-bearing lemon trees should ordinarily be confined to control of the framework arrangement of the trees, removal of dead or decadent branches which might injure the lemons through

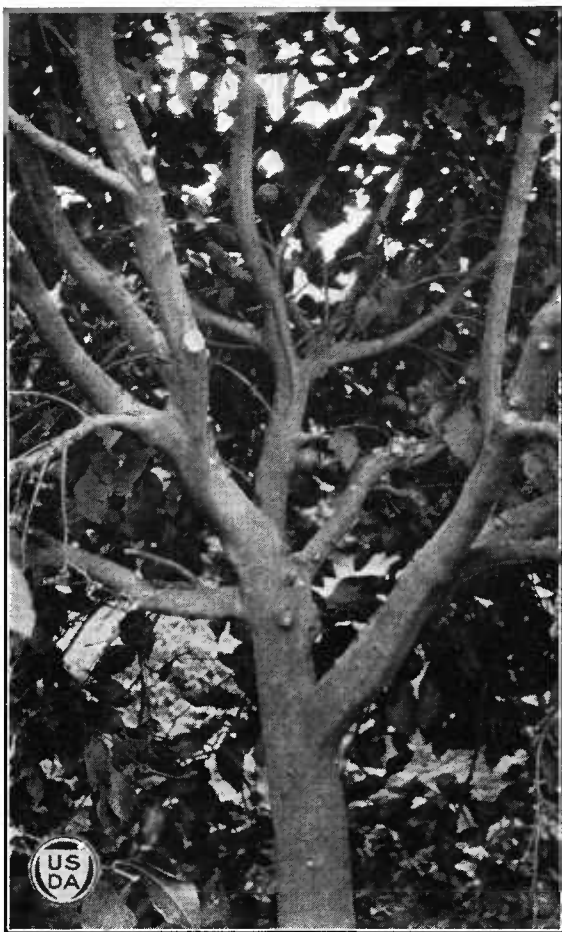


FIG. 6.—The interior framework arrangement of the Lisbon lemon tree shown in Figure 5. Some of the branches of this tree have been cut out in order to photograph the framework.

scratches or bruises, and special treatment of injured or decadent trees, as discussed under separate headings. A typical unpruned lemon tree is shown in Figure 11, a lightly pruned tree in Figure 12, and a severely pruned tree in Figure 13. Subsequent production of pruned trees for a 5-year period was cut down about in proportion to the severity of pruning.

RENEWAL OF OLD NEGLECTED AND DECADENT TREES.

A study by the writer during 1913 of navel-orange trees in the vicinity of Bahia, Brazil, where orchards of this type have been maintained for about a century, revealed the fact that the older trees in these orchards had been renewed periodically by cutting off most or all of the tops and encouraging the growth of new frame-

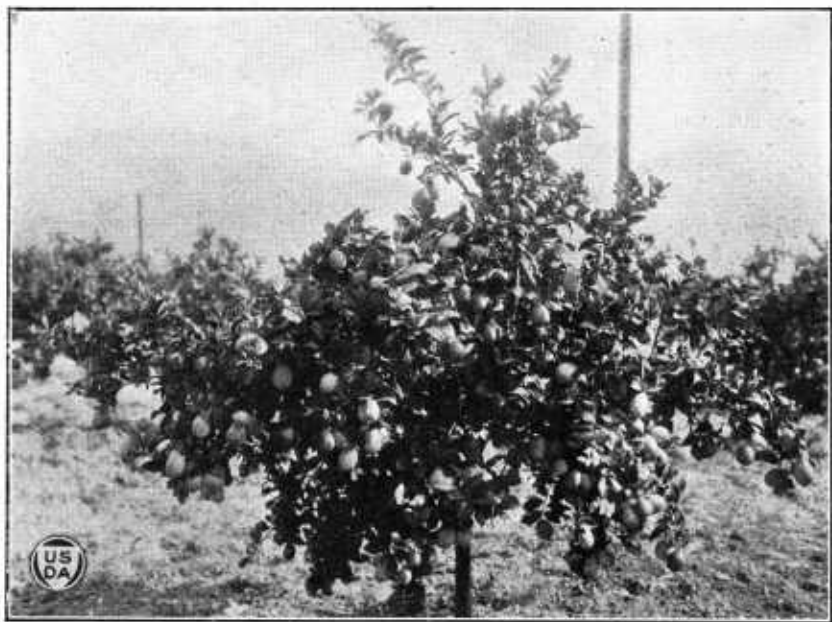


FIG. 7.—Productive strain of Eureka lemon tree 2 years old, showing little or no need for pruning in an inherently fruitful citrus tree.

work and fruit-bearing branches. Very little or no pruning other than occasionally cutting out dead or other objectionable branches was practiced between the periods of tree renewal.

As a rule, the trees in the old orchards had been renewed at intervals of about 25 years. Growth of the renewed trees, cut back in about the same degree as for top-working, proved to be vigorous, healthy, and fruitful. In several of the oldest orchards evidence was found that some of the trees had been renewed in this way at least three times with apparent success.

A study of results of tree renewal with old and neglected citrus trees in California, similar to that practiced in orchards at Bahia, has shown that it is frequently successful if environmental conditions are favorable. Cutting back should be done in the late winter or early spring. Tops of trees to be renewed are usually cut back

very much in the same way as for top-working, except healthy horizontal and drooping branches near the heads of trees, which are usually allowed to remain undisturbed. Figure 14 shows decadent Washington Navel orange trees cut back very severely for the purpose of tree renewal. New growth following severe cutting back is trained in a manner similar to that of young trees, in order to develop strong and well-balanced tree tops. Trunks and portions of limbs left after the tops have been removed are protected by a coating of whitewash¹ applied immediately after the pruning.



FIG. 8.—Eureka lemon tree 3 years old grown from a bud secured from an unproductive parent tree. Such trees require frequent pruning in order to thin the vegetative growth and cut back the long weak limbs. Note the entire absence of fruit on this tree in comparison with the productive tree shown in Figure 7.

The advisability of attempting to renew decadent or old neglected trees which have become unproductive for various reasons must be determined through a consideration of local tree and environmental conditions. If trees are very badly diseased or injured by insect attacks, or if they show signs of decadence by reason of mottle-leaf, chlorosis, or related troubles, it is probable that tree renewal will be

¹ The formula commonly known as California tree whitewash is as follows: 30 pounds of quicklime, 4 pounds of tallow, 5 pounds of salt. Dissolve the salt in a little water, melt the tallow, and mix it with the salt solution. Slake the lime and add the salt and tallow mixture. Dilute with enough water to make the mixture flow well. It can be applied by hand with a brush, but when a large number of trees are to be treated it is most economically applied through a spray nozzle by means of a power sprayer.

of little value in most instances. Most leading growers now prefer to remove badly diseased trees and replace them with healthy young trees.

In the case of older trees which have become unproductive by reason of neglect, poor cultural treatments, or other environmental conditions and where the bark of many of the limbs has become hidebound, tree renewal by severe pruning has been used with good results in many instances. Where the orchard to be renewed contains off-type trees of undesirable strains these trees should be top-worked.

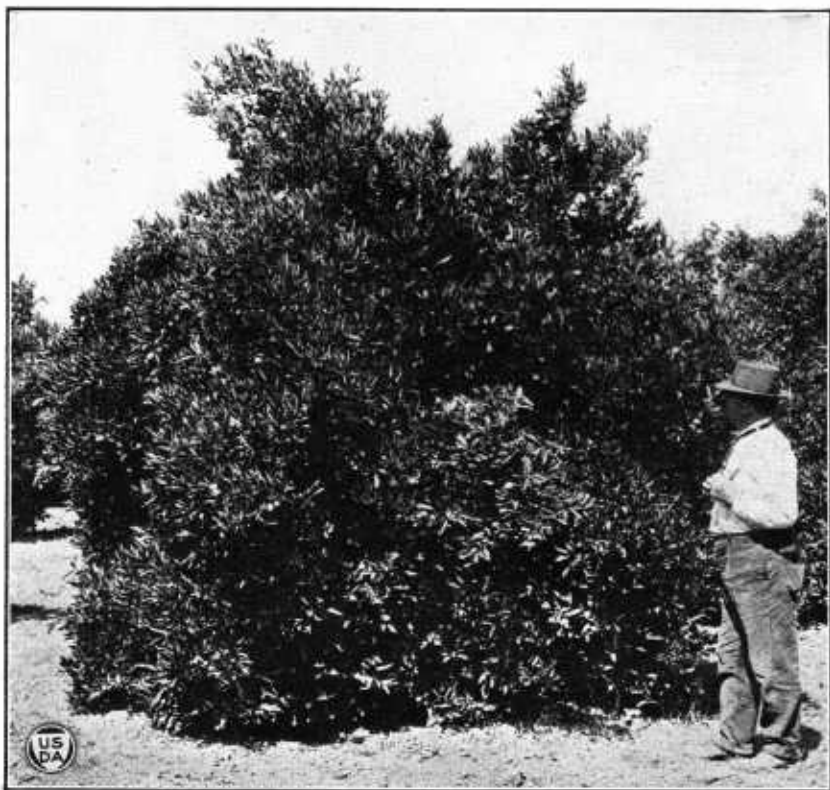


FIG. 9.—Unpruned Washington Navel orange tree 11 years old.

This plan provides for improving the strain characteristics of the trees as well as for securing the benefits of tree renewal. If bark conditions on the trees are unsatisfactory for top-working, sprouts should be grown after cutting back the framework limbs, into which selected buds can be inserted. Directions for top-working citrus trees can be found in *Farmers' Bulletin 794, Citrus-Fruit Improvement: How to Secure and Use Tree-Performance Records*.

PRUNING FROST-INJURED TREES.

Low temperatures have been responsible for occasional injuries in varying degrees to some of the growth on citrus trees in many dis-

tricts in the Southwest. Usually only the younger and more tender growth is killed by low temperatures. As a rule, the more severe frosts occur during December and January. Under these conditions the injured growth should be left untouched until after new growth has started during the subsequent spring months. It is then possible to distinguish clearly the injured growth. It is a good plan to cut off dead and badly injured branches an inch or more back of the area of visible injury, in order to make sure of removing all dead or injured growth.

In the case of split bark on trunks or larger limbs the injured areas may be treated and their recovery hastened by carefully wrap-



FIG. 10.—Severely pruned Washington Navel orange tree, showing the exposure of the fruits to sunburn, wind damage, and other injuries. This tree did not recover and attain normal fruit production until three years after the pruning.

ping the wounds with twine, strips of cloth, or other similar material so as to bind the loose bark to the wood. Twine or strips of cloth should be wound spirally around the trunk or limb, leaving the greater portion of the bark uncovered and allowing free access of air but holding the loose bark firmly against the wood. This work must be done promptly after injury. If delayed for some time the wrapping will not be beneficial. Such treatments should be examined occasionally in order to detect possible molding or other difficulties. After several months the wraps should be removed at a time when the dried-out patches show clearly the extent of damage. All dead bark should then be carefully cut away and injured areas thoroughly

cleaned. After cleaning, Bordeaux paste² should be applied in order to disinfect the wounds and prevent development of diseases. Small splits on branches or tree trunks can be left untreated, because they will usually heal without any particular care, or if they do not their injurious effect is of little consequence. Cost of treatment will probably be greater than any benefit which might arise from it.

Frosted trees are sometimes pruned before the extent of their injury can be definitely ascertained. In this case pruning often has to be repeated later in the season, thus increasing cost. Further-



FIG. 11.—Unpruned Eureka lemon tree 11 years old, for comparison with Figure 13.

more, when the injured growth is removed immediately following a freeze climatic conditions may be such as to encourage new growth, which is likely to be killed or badly hurt by subsequent frosts. If injured trees are left until new growth has started during spring and early summer months, injured branches can be safely cut out. If trees are largely defoliated by reason of low temperatures, trunks and branches should be covered with whitewash to protect them from sunburn. A badly frosted and defoliated Eureka lemon tree is

² The standard formula for Bordeaux paste is as follows: Dissolve 1 pound of bluestone (copper sulphate) in 1 gallon of water in a wooden or earthen vessel. This can best be done by hanging it in a sack near the top of the water. Slake 2 pounds of quicklime in about half a gallon of water. Stir together when cool, making a light-blue mixture of about the consistency of whitewash. If the mixture turns to some other color before application it is an indication that something is wrong. Mix a fresh supply every day or two, as the mixed paste tends to deteriorate with age. Apply with a brush.

shown in Figure 15. A pruned frost-injured Eureka lemon tree is shown in Figure 16. New growth of the pruned tree one year after pruning is shown in Figure 17. Figures 18 and 19 show the recovery in neighboring Washington Navel orange groves of typical trees which were properly and poorly pruned, respectively, following a severe freeze. In lightly frosted bearing trees small injured branches may be removed after danger from further frost damage has passed.

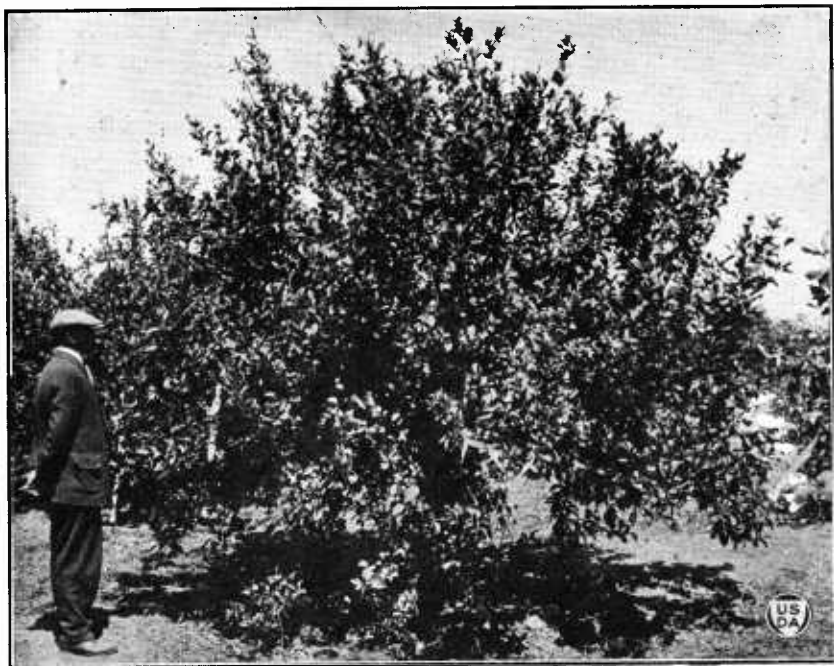


FIG. 12.—Lightly pruned Eureka lemon tree 11 years old. Compare this with the unpruned tree shown in Figure 11.

PRUNING DISEASED AND INJURED TREES.

The most common fungous diseases attacking citrus trees in California and Arizona include brown-rot, or *Pythiacystis gummosis* (*Pythiacystis citrophthora*); mal di gomma, or foot-rot; and psorosis, or California scaly bark, which occurs mostly on oranges and sometimes on grapefruit.³

The portions of trees injured by these and similar diseases oftentimes may be successfully treated by carefully cutting away the diseased tissues and applying suitable antiseptic materials, such as Bordeaux paste. Smaller branches suffering from these diseases can usually be pruned off, taking care to make the cuts well back of diseased areas. This work usually requires special experience, and it is generally most economical to secure trained pruners for it.

³ A description of the injuries caused by these diseases is given in Bulletin No. 262 of the California Agricultural Experiment Station, Citrus Diseases of Florida and Cuba Compared with Those of California, by Howard S. Fawcett.

Small branches which have been badly injured or killed as a result of insect attack should be pruned off and the cause of the injury eliminated. This pruning will usually stimulate active new growth and hasten the recovery of the affected trees. In trees partly defoliated and badly injured by scale attack, judicious pruning before fumigation will usually prove to be beneficial in stimulating new and vigorous growth.

Tree trunks or large roots girdled or partly girdled by mice, gophers, or other rodents can usually be treated successfully if the treatment is done soon after the injuries have been made. Trees with badly girdled trunks generally can be saved by inarching or bridge grafting. The inarching process is illustrated in Figure 20.

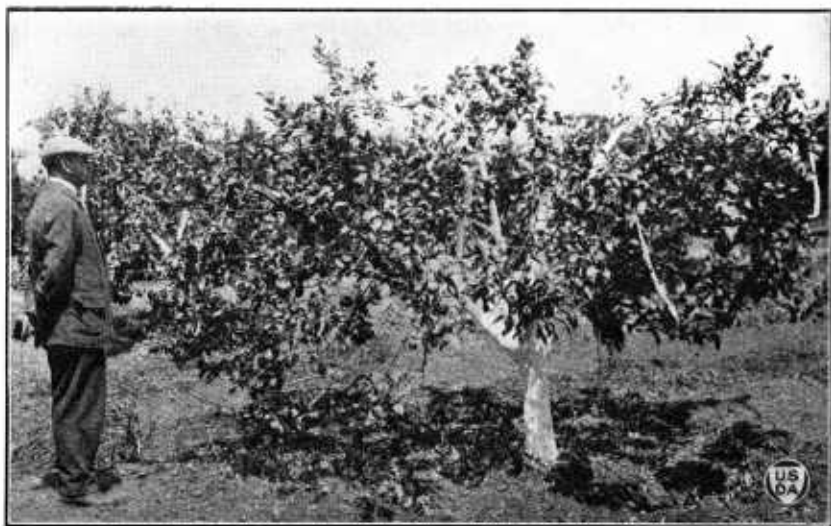


FIG. 13.—Heavily pruned Eureka lemon tree 11 years old, for comparison with Figure 11.

Injured edges of the bark of partly girdled trunks should be smoothed, the wounds covered with grafting wax or similar protective material, and the trees pruned severely. If injured trees have been seriously affected, it is usually desirable to cut them back during the early spring months, somewhat in proportion to the degree of injury. These injuries are frequently accompanied by partial defoliation of the trees, in which event the trunks and main branches should be coated with whitewash in order to protect them from sunburn.

Large branches are sometimes broken by cultivators or other implements of tillage. These branches should be cut off as soon as the injuries are discovered, in order to avoid further possible damage to the trees.

SEASONS FOR PRUNING.

The season best adapted for pruning depends to a considerable degree upon the character and object of the work. The time for heading young trees depends largely upon when the budding was

done and upon growth conditions. Trees which are budded in fall and early spring can usually be headed during the first summer. Late spring and early summer budded trees are usually headed during the same summer or early the following spring. As a rule, young trees should be headed when they reach the proper height and when the branching growth stimulated by heading is not likely to be injured by frost or extreme climatic conditions. Spacing the growth stimulated by the heading-back process is done usually the same season as heading back, but sometimes this work is deferred until the following season.

The removal of suckers, crossed limbs, or other objectionable branches is usually done during late winter or early spring, when the

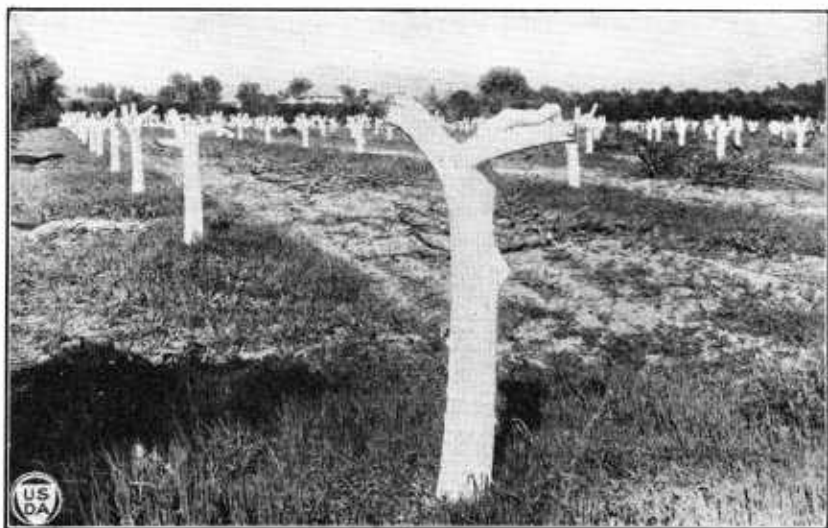


FIG. 14.—Neglected and decadent Washington Navel orange trees cut back very severely in order to grow new tops. The pruning was done in February, 1914, and was followed by thorough cultivation and liberal fertilization of the soil. These trees grew satisfactory new tops and recovered normal fruit production within five years. It is sometimes questionable whether or not this extreme treatment is more desirable than to replant the orchard with young trees.

trees are in their most dormant condition. Thinning bearing branches in order to stimulate the rate of growth of fruits or to influence their size is usually done while the fruits are small and immature during spring or early summer.

Control of the growth of leaders and other growth to secure strong and well-balanced trees and to keep the development of tree tops so that the fruits can be conveniently picked is usually effected by pruning during late winter or early spring after danger of frost injury has passed. Location of the orchard with relation to frost damage is an important factor in determining the time for carrying on this work.

The cutting out or other treatment of branches seriously damaged by fungous diseases or insect pests is usually done whenever these conditions are discovered. Whenever possible, this work should be done during late winter or early spring.

The renewing of old, neglected, or decadent trees by severe pruning should be done during late winter or early spring, so that growth stimulated by this pruning is not likely to be injured by excessively low or high temperatures or other weather hazards.

In general, the seasons selected for pruning citrus trees in the Southwest in order to secure the best results should be governed by the location of the orchard with respect to frost, heat, or wind in-

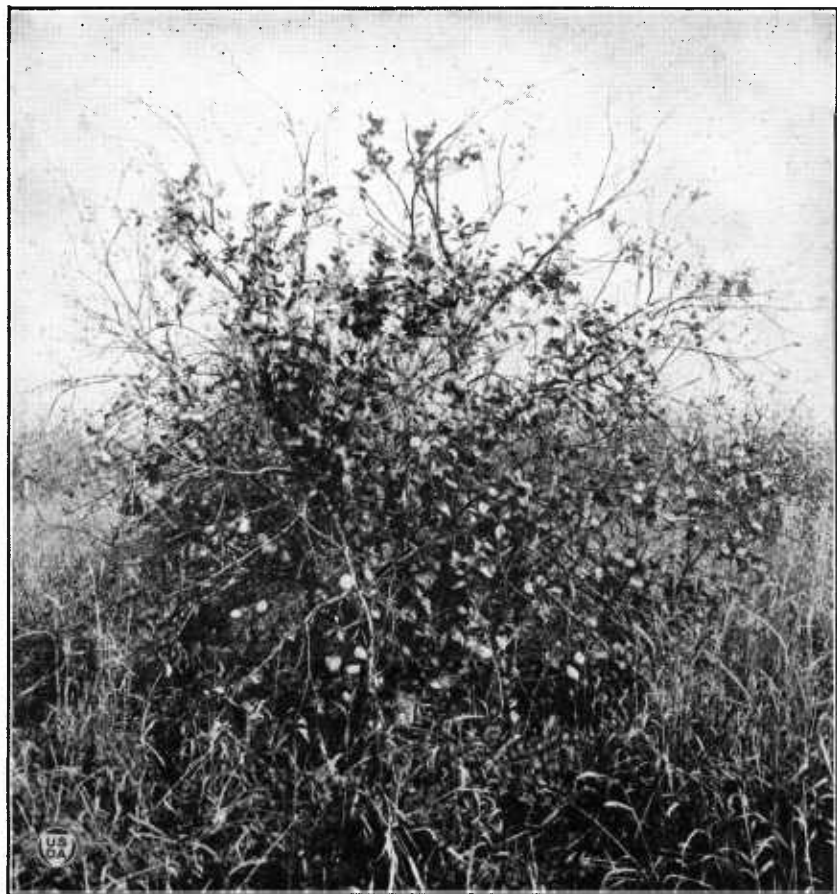


FIG. 15.—A Eureka lemon tree severely injured by low temperatures, showing its defoliated condition immediately after the freezes of the winter of 1912-13.

juries, the age and condition of fruits borne by the trees, the characteristics of growth to be removed, the relation of this work to other orchard activities in order that labor may be employed most efficiently and economically, and the local experience showing the best results from a particular season for this work.

PRUNING METHODS AND PRUNING TOOLS.

The art of pruning includes efficient handling of pruning tools, intelligent selection of branches to be cut out so as to leave well-distributed growth in the tree top, making smooth cuts at the proper

location and angle so that the cut surfaces will heal over without subsequent damage to the trees, protection of pruned trees from sunburn, and treatment of wounds caused by pruning in order that they may be protected from infection by disease. Suitable pruning implements are needed to make good cuts. The treatment of cut surfaces immediately after pruning aids in the callusing and healing over of wounds.



FIG. 16.—Eureka lemon tree badly injured by low temperatures and severely pruned three months after the frost, in order to remove the dead and injured growth. The condition of this tree one year later is shown in Figure 17.

PRUNING IMPLEMENTS.

The most commonly used and most efficient citrus-pruning implements and supplies include (1) long-handled shears; (2) short-handled shears; (3) saw; (4) ladder; (5) file, whetstone, and repair tools; and (6) long leather gauntlets.

Cutting and sawing implements should be kept sharp and in the best possible condition for making smooth and clean cuts. For this purpose it is advisable to have whetstone, files, or other sharpening tools in a bag or box convenient for frequent use in the field during pruning work. Wherever possible, it is advisable to secure shears and saws with replaceable cutting or sawing parts. In this way the cutting or sawing blades when badly worn can be replaced with a minimum of expense. Typical implements suitable for this work are shown in Figure 21.

It has also proved economical in the long run to buy cutting and sawing implements of the best grade of steel. Such implements not only last longer than inferior ones but also enable the pruner to make more rapid and efficient cuts and thereby accomplish better work than with tools of lower grade.

Pocket or other knives with large blades, similar to those shown in Figure 21, a chisel, and a gouge with cutting edges of suitable shape can sometimes be used to advantage in smoothing the surfaces of large



FIG. 17.—Eureka lemon tree, showing the growth of one year following severe pruning to cut out frost-injured branches. The condition of this tree immediately following the pruning is shown in Figure 16.

cuts or in cleaning out diseased tissues. Cuts with smooth surfaces and edges callus and heal over more rapidly than those having rough surfaces or ragged edges.

Repair or replacement parts, sharpening devices, and extra implements should be kept on hand in the orchard where work is being done. Tools in actual use should be gone over frequently by some one capable of repairing or adjusting them in order to keep them in condition for use as nearly perfect as possible.

Long strong leather gauntlets are essential in citrus work, in order to protect the pruner's hands and arms from injuries by thorns or sharp branches.

Orchard ladders for reaching parts of trees not easily accessible from the ground are necessary for good pruning. These ladders should be as light as is consistent with adequate strength and should have three legs, so as to stand firmly in a convenient position for reaching the growth to be removed. Such ladders are easily moved about and can be quickly placed in convenient positions for pruning.

PRUNING CUTS AND THEIR TREATMENT.

The art of pruning includes making smooth cuts at the proper angle and in the right position. When it is necessary to remove



FIG. 18.—A Washington Navel orange tree two years after having been properly pruned following a severe freeze.

large branches the cuts should be made as close as possible and parallel to the limbs or trunks of the trees from which arise the branches to be removed. Stubs or projecting ends should be avoided in every possible instance. Square cuts with horizontal exposed surfaces are very undesirable as a rule. Bruises, scratches, and other injuries to the bark or growth of the tree back of the cuts or elsewhere made by pruning implements, shoes, or from other causes indicate very poor pruning practice, and great care should be used to avoid them.

Improperly made cuts are usually due to inexperience in pruning, carelessness on the part of pruners, dull or defective pruning implements, or by reason of attempting to make cuts from a wrong position. Damage to the future development of trees from poor cuts is likely to be very great. The writer is familiar with many instances in citrus orchards where trees have become diseased fol-

lowing poorly made pruning cuts. The treatment of such trees in order to cut out the decayed wood which developed as a result of disease infection has cost the owners several dollars per tree for their subsequent treatment and care. These trees were often found to be so seriously diseased and injured that they had to be removed from the orchard.

When it becomes necessary to remove large branches careful work is required in order to avoid splitting them and injuring the trees.

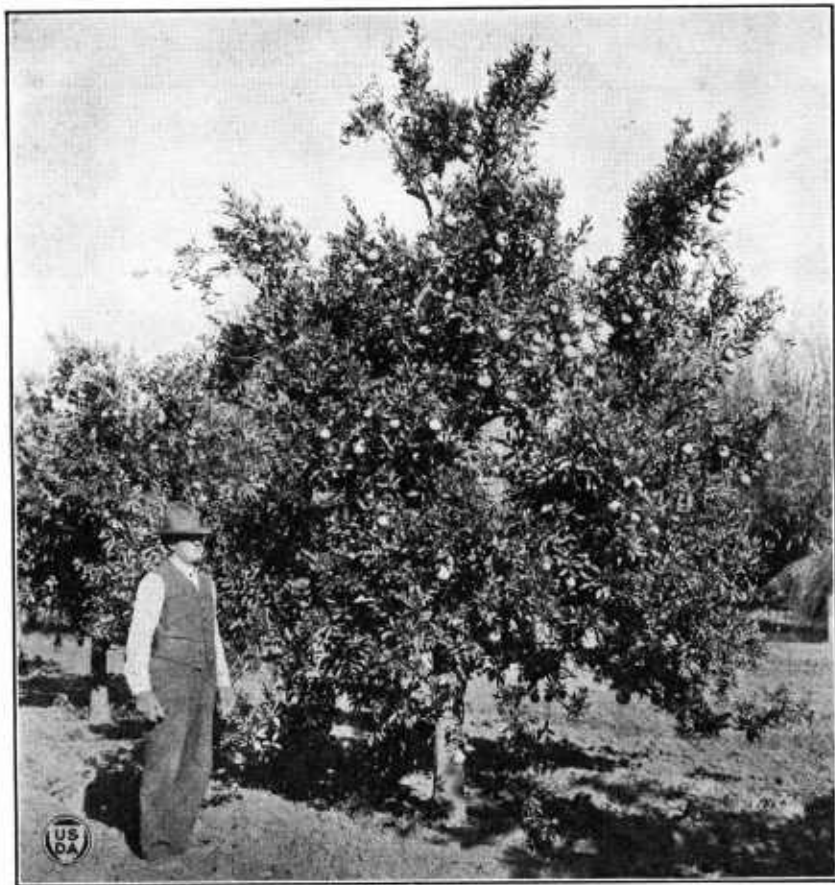


FIG. 19.—Washington Navel orange tree two years after having been poorly pruned following a severe freeze. This tree is located just across the street from the one shown in Figure 18.

In this work the under side of the branch should first be cut part way through with the saw, usually about one-quarter of the diameter of the limb, as shown in Figure 22. Then the upper cut with the saw should be made a little forward of the under one. In this way the branches will break off when nearly or quite sawed through without any danger of splitting or injuring the tree limbs or trunks. After the large limbs have been removed stubs remaining should be sawed off close to the trunk or limb from which the branch was

removed and the surface and edges of the cut should be carefully smoothed with a knife or chisel, as shown in Figure 23, in order to facilitate the healing over of the wound. A large pruning cut partly callused and healed is shown in Figure 24.

Small cuts made in pruning citrus trees, those of half an inch or less in diameter, can usually be left without treatment under the



FIG. 20.—Inarching a lemon tree. The seedling sour-orange trees used for the inarching process are set in holes near the tree trunk, and long contacts of the cambium layers of the seedling stems and the tree trunks are made. A homemade arrangement for keeping the wax warm and soft is shown at the right.

climatic conditions of the Southwest. General experience in pruning is that the larger cuts should be protected by covering freshly cut surfaces with grafting wax or other suitable material. In some instances large unprotected cut surfaces have healed over without protection in an apparently satisfactory manner; as a matter of safe practice, however, wounds of more than half an inch in diameter should be protected. The expense of this operation is small, and

the insurance against decay developing from larger cuts justifies this practice.

Several protective materials have been commonly used in covering pruning cuts and tree injuries in citrus trees in the Southwest, including grafting wax, asphalt paint, tar, and several proprietary compounds. Of these, grafting wax has given the most universal satisfaction. The method of preparing grafting wax for use in protecting tree wounds varies greatly, according to the ideas and experience of the individual pruners and users. A standard method

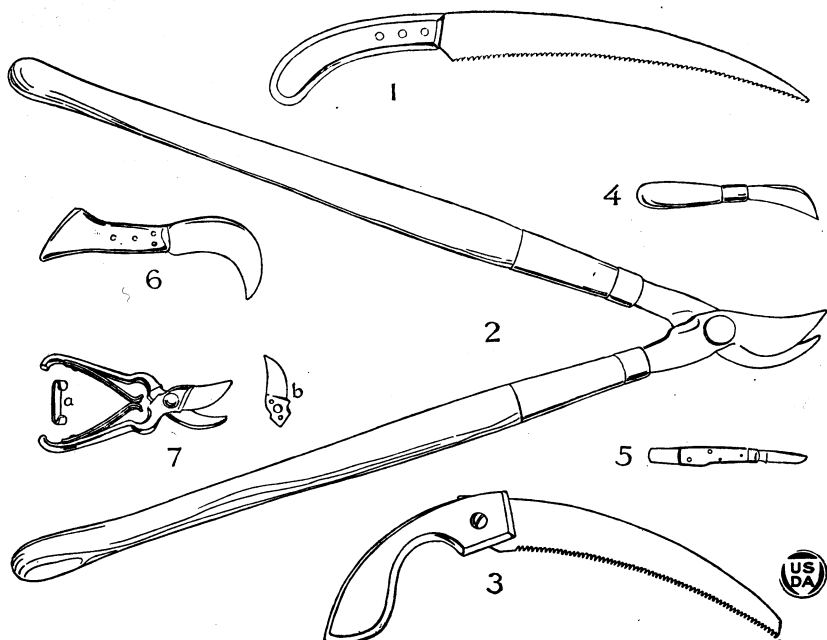


FIG. 21.—Pruning implements used in connection with the management of citrus trees: 1, A sharp-pointed type of saw; 2, long-handled shears for the removal of large limbs; 3, a folding saw frequently used because it can be conveniently carried; 4, a pruning knife; 5, a budding knife; 6, a heavy hawk-billed knife; and 7, short-handled pruning shears (a, clasp; b, extra blade).

is to melt together 1 part of tallow, 1 part of beeswax, and 2 parts of rosin. This wax should be stirred or pulled until it develops a yellow grain. It will keep indefinitely. An experienced California citrus pruner uses a grafting wax for covering tree wounds made by melting together equal parts of beeswax and rosin. For inarching, the mixture is made up of 2 parts of beeswax to 1 of rosin. During use a quantity is kept warm and plastic by heating it with a slow fire, in which condition it can be applied with a brush. Care should be exercised to cover fully all of the wounded area.

The stove or other arrangement for use in heating grafting wax or similar materials and keeping them in condition for application can frequently be made out of a small worn or cast-off household stove or burner. A large square metal oil can is frequently arranged for this purpose, a lower pan holding the fire and an upper pan the material to be warmed. A homemade arrangement of this sort is shown

in Figure 20. An ordinary paintbrush is needed for applying the melted grafting wax or other similar materials to the freshly cut surfaces.

The failure to protect large cuts made during pruning sometimes leads to decay or heart-rot in the trunks or main limbs. In this event it is necessary in order to save the trees to dig out and clean the decayed areas carefully. If the cavities are small the surfaces

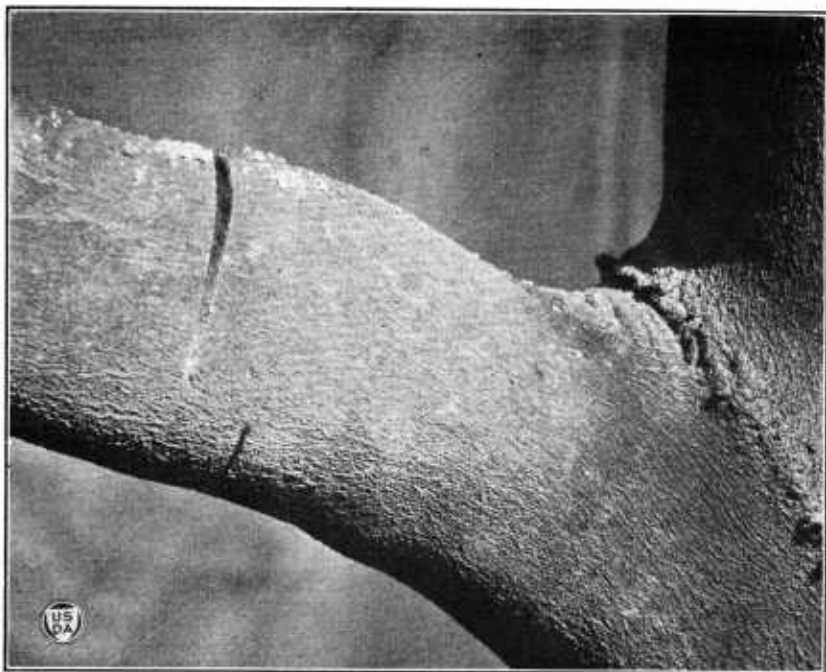


FIG. 22.—Sawing off a large citrus limb. The first cut is made on the under side. The cut on the upper side is made in front of the under one, so that when the limb breaks off there is no danger of splitting or injury to the tree. The stub thus made is then cut off at the proper place, as shown in Figure 23.

should be covered with grafting wax, tar, or other suitable material after the removal of all decayed tissue. If the cavities are large they should be thoroughly cleaned and then disinfected with some effective material such as creolineum, after which they may be filled with cement. The treatment of heartwood rot in citrus trees resulting from careless pruning is very expensive, so that every precaution should be taken to avoid the necessity for it.

CARE OF PRUNED TREES.

Lightly pruned citrus trees in the Southwest require no particular care after pruning. Severely pruned trees, where considerable of the growth has been cut out, do need some protection from sunburn, wind, or other exposure. In the case of small trees the heavily pruned ones may be protected to advantage by wrapping the trunks with burlap or other cloth, paper, or similar wraps, arranging the wraps so as not to restrict the growth of the trees in any way. Cloth or paper wraps can usually be wound about the trunks in a

spiral way and loosely tied, so that they will easily give way to the expansion of the trunks. It is also important to inspect the bark under such wraps occasionally, in order to make sure that they do not harbor scales or other insect pests or encourage the development of fungous diseases. Trunks and main limbs of larger citrus trees should be covered with whitewash as soon as possible after severe pruning is done.

It is a mistake to assume that heavily pruned trees do not require fertilization or other usual cultural care. They should be given ade-

quate care to hasten their recovery and promote their best development. If pruned trees are left for a year or more without systematic cultural attention a spindling and undesirable growth condition is likely to develop.

INDIVIDUAL TREE CARE.

In order to give citrus trees individual care in pruning it is advisable to number every tree, so that each particular tree needing attention can be found and treated at the proper time. The tree-numbering system which has given best results

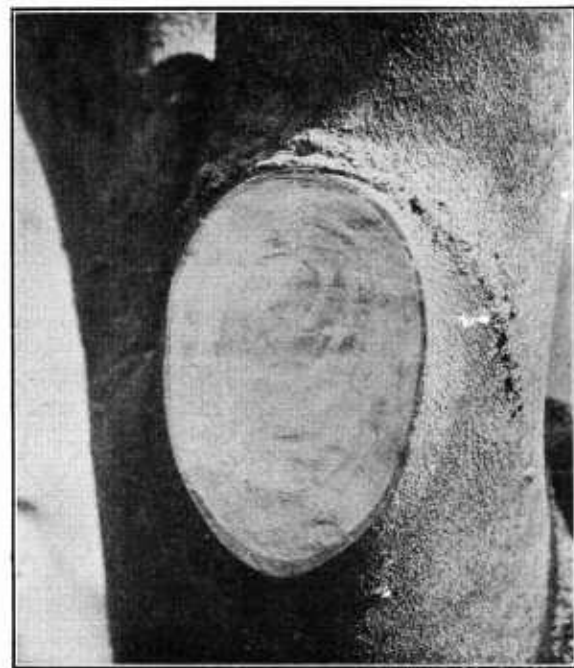


FIG. 23.—A smooth surface and close cut made in sawing off a large citrus limb. The cut is parallel to the tree trunk. It was covered with grafting wax immediately after the operation.

is as follows: Each tree is given a number consisting of three parts—(1) number of the orchard or block, (2) number of the row in which the tree occurs, and (3) position of the tree in the row, always counting from some fixed point, such as irrigation head or other permanent landmark. A tree located in block 6, row 12, and the sixteenth tree in the row will have the number 6-12-16. This number can usually be painted upon the tree trunk, using pure white-lead paint and a lettering brush. The numbers should always be placed in the same relative position on the trees, so as to be easily found at any time. The figures should be plain and as large as possible, in order to simplify their identification. On larger tree trunks the numbers

can be arranged in a vertical position, one part below another, as 12

6
16.

With very small trees each figure can be placed in a vertical column, with dividing lines between the parts of each number.

In all orchard-inspection or cultural work where individual trees are observed with broken limbs, objectionable branches, or attacked by fungous diseases, insect pests, or rodents, the numbers of trees needing attention can be recorded in a field notebook. When the proper time for pruning and treatment arrives or when opportunity offers, the trees needing treatment can be found with certainty and without loss of time by aid of the tree numbers.

FREQUENCY OF PRUNING.

Frequency of pruning depends largely upon the inherent characteristics of trees, soil, and cultural and climatic conditions, particularly with reference to possible frost and heat injuries and in some degree with relation to season of fruiting.

With inherently fruitful strains of citrus varieties the necessity for frequent and severe pruning is largely eliminated.

Trees growing on very rich soil and under favorable cultural conditions, promoting active vegetative growth, may need more frequent pruning than those planted on lighter soils or those having less fertilization or inferior cultural treatments.

Frost and heat injuries must be treated by pruning at the proper time. The pruning of citrus trees in locations where frost or heat injuries are to be expected should be such as to minimize the stimulation of tender vegetative growth likely to be hurt by subsequent adverse weather conditions.

Severe pruning should not be done frequently, usually not oftener than once during a period of several years. This pruning when done during late winter or early spring should be followed later in the same season with thinning and other care of the growth stimulated by the pruning.



FIG. 24.—A large wound made in pruning, showing the extent to which it had healed three years after it was made.

It seems likely that all citrus trees should be gone over at least once every year in order to give them any necessary pruning treatment, such as removing objectionable growth, control of the framework in order to secure well-balanced tops, and to cut out dead and decadent branches.

DISPOSAL OF PRUNINGS.

Citrus prunings in California and Arizona orchards have usually been disposed of in the following ways: (1) By burning, (2) by piling them under the trees, and (3) by cutting them up and plowing or disking them into the orchard soil.

The practice of burning prunings from citrus trees has largely been abandoned in the Southwest, except in the case of growth which is known to harbor insect pests or that attacked by fungous diseases. In order to burn the branches cut off during pruning, it has usually been necessary to haul them out of the orchard to a safe distance, so as to avoid possible heat damage to the trees. This method is usually considered to be a wasteful one, and most growers now use the prunings for improving orchard soil conditions.

A considerable number of citrus growers in the Southwest have tried the plan of piling prunings under the trees. It was thought that by using this method the prunings would decompose slowly and act as a mulch for the soil under the trees, thus preventing weed growth and keeping these soil areas in good tilth. Owing to the tendency of field mice and other rodents to hide and nest under prunings disposed of in this manner and the serious injuries to the trees from girdling under these circumstances, this method generally has been given up.

The most satisfactory method of disposing of citrus-tree prunings in California and Arizona is to incorporate them in the orchard soils. In small orchards the larger limbs can be cut up into pieces so small that they can be plowed or disked under and satisfactorily covered.

In larger orchards, where the prunings from a large number of trees are to be cut up, this work can be most economically done by running them through a suitable cutting machine, such as a silage cutter. This machine can be mounted on a movable truck with a gas engine to operate it. The prunings are run through a cutter so arranged as to cut them up into small pieces which can be easily plowed or disked under. When pruning is done during winter or early spring before plowing or cultivation has begun, the prunings can be cut up and distributed over the soil between the trees at the time of pruning. The partly decomposed prunings can be plowed or disked under later or at the regular season for this work.

COST OF PRUNING.

In a citrus orchard located at San Dimas, Calif., which contains 21 acres of Eureka lemon, 17 acres of Valencia orange, and 6 acres of Marsh grapefruit trees, or a total of 44 acres, the total expense of pruning the trees for the first five and a half years after planting was \$358.35. The total pruning cost in this case amounted to an average of \$8.14 per acre, or an average annual expense of \$1.48 per

acre from the time the orchard was planted in the spring of 1916 to the autumn of 1921. The expense of pruning for the first two years in this orchard was very light. The trees were all grown from buds secured from superior parent trees selected for propagation on the basis of their performance records.

The cost of pruning ordinary young citrus trees, particularly those of the vegetative strains, is much higher than that shown for the superior fruitful-strain trees mentioned in the foregoing statement.

The cost of pruning citrus trees varies so much, on account of the system of pruning used, because of the different rates of wages paid to pruners in different districts, and by reason of the fact that the time required to prune trees varies with regard to individual-tree characteristics and seasonal growth conditions, that no definite statement of expense can be presented which will apply to all orchard conditions. Under ordinary orchard conditions with normal healthy trees the annual cost of pruning full-bearing orange and grapefruit trees has amounted to about \$10 per acre and for full-bearing lemon trees to about \$20 per acre.

The important fact should be noted that the expense of pruning inherently fruitful citrus trees is very much less than that of pruning the rank-growing unfruitful and vegetative trees illustrated in Figure 8. This difference is a very important item in the cost of orchard maintenance and should be given careful consideration by every prospective citrus planter.

EFFECTS OF PRUNING.

The effects of pruning upon bearing citrus trees include (1) stimulation of vegetative growth, (2) increase of rate of growth of the fruits, and (3) reduction of yield. The effects vary somewhat in proportion to the severity of pruning with regard to cultural and individual tree conditions and other factors. The desirability of any pruning practice can best be determined through a study of the effect of pruning upon behavior of the trees.

EFFECT OF PRUNING UPON TREE GROWTH.

Pruning citrus trees, particularly severe pruning, stimulates vegetative growth. When a part of one of the larger branches is cut off, dormant buds back of the cuts usually develop and start growth. The rate of growth of these branches is greater than that of the branches on unpruned trees under comparable conditions, at least during their first period of growth.

In the case of severe pruning the pruned trees do not usually reach the same volume as the unpruned trees, or at least not for a considerable period of time. There is some evidence to show that the severe pruning of tops is accompanied by a corresponding slowing up of root development. Therefore severe pruning seems to result in a permanent reduction of size of both top and root areas.

EFFECT OF PRUNING UPON THE GROWTH OF FRUITS.

The rate of growth of fruits borne by pruned citrus trees is usually greater than that of fruits produced by unpruned trees. There is no available evidence to show that the ultimate size of the mature fruits

from pruned trees is different from that of the fruits borne by unpruned trees. In lemons, where the fruits are picked before maturing upon reaching a certain size, the influence of pruning upon the rate of growth may be important in that it will enable the grower to stimulate the rate of growth in order to make the lemons reach marketable size at a particular season. Otherwise the importance of pruning citrus trees in so far as it relates to affecting the size of fruits is almost negligible.

EFFECT OF PRUNING UPON FRUIT PRODUCTION.

The effect of light pruning, such as the removal of suckers and dead or decadent branches, upon the yield of citrus trees is usually almost negligible. If healthy fruit-bearing growth is cut out the yield is almost certain to be lowered.

The effect of severe pruning upon healthy bearing citrus trees has usually reduced the production of fruit about in proportion to the severity of the pruning. Unless there are apparent compensating advantages in tree growth or shape it seems that such pruning should be avoided with normal trees. The loss in yields is usually brought about through the reduction of the leaf area, with a consequent loss of power of carbon assimilation, and by the unnecessary cutting off of fruit-bearing growth.

Thinning the fruits by pruning has shown little or no apparent improvement in the ultimate size or the commercial grade of the ripe fruits. Where trees have a large number of dead branches which might injure the adjacent fruits through scratches or bruises, it seems certain that under most circumstances this growth should be removed by careful pruning. It is questionable from an economic standpoint whether it is profitable to cut out small numbers of dead branches unless they favor the development of fungous diseases or harbor insect pests.

SUMMARY.

The principal objects of pruning citrus trees are to train the growth of young trees so as to provide a strong well-balanced framework, to remove objectionable branches, to thin the growth, to control diseases, to aid in the recovery of trees from insect or other injuries, and to renew old and decadent trees.

Young citrus trees should be headed in the nursery or when they reach a height of about 30 inches above the ground.

The main framework branches should be arranged in a spiral around the tree trunk several inches apart and should consist of not less than three nor more than five limbs.

Two methods of arrangement of framework limbs stand out as the dominant ones as a result of experience in this connection. One provides for training these limbs in an upright position, commonly called a vase shape, which seems to produce stronger trees, more resistant to adverse weather conditions. The other has for its object the development of spreading and comparatively low growing trees, usually referred to as having a bowl shape, more easily treated for insects and diseases, and providing for easily accessible fruits.

The early fruit-bearing growth of young trees should be left undisturbed, so as to encourage early fruiting.

Full-bearing healthy orange and grapefruit trees should not be pruned except to remove dead or decadent growth, to remove suckers or objectionable branches, and to guide the development of a strong and balanced tree top.

Full-bearing healthy lemon trees should be pruned along the same lines as similar orange and grapefruit trees, except where it is desirable to hasten the rate of growth of the fruits in order to market them at a particular season.

Old or decadent trees which have become somewhat unproductive by reason of the condition of the vegetative growth may sometimes be renewed by cutting off the old tops and growing new ones. The method of cutting back such trees and caring for the new growth is similar to that in the case of top-worked trees.

Frost-injured trees should not be pruned until sufficient time has elapsed after the freeze so that the lines of demarcation between the injured and healthy areas can be clearly determined. Killed and badly injured branches should be removed and split-bark patches in the trunks or main limbs treated in order to hasten recovery and prevent fungous infection.

The best season for citrus pruning in the Southwest is during the spring and early summer. Follow-up thinning and related work usually can best be done during early summer.

The most important pruning implements are a saw, a pair of long-handled shears, a pair of short-handled shears, a ladder, and strong gauntlet gloves to protect the hands and arms of the pruners.

Pruning cuts should be carefully made, so as not to injure the bark or wood of the tress. Smooth sloping cuts are evidence of experienced work.

All of the larger pruning cuts should be covered with grafting wax, asphalt paint, or similar material as soon after the cuts have been made as possible. Small cuts need not be treated in this way.

Pruned trees should be given adequate fertilization, irrigation, and cultural treatments. Pruning is not a substitute for any phase of cultural care.

All severely pruned or otherwise partially defoliated trees where the trunks or branches are exposed to the sun and weather should be coated with a suitable whitewash.

Each tree, on account of the individuality of trees, should be treated with regard to its particular requirements and apparent needs.

The frequency of pruning depends upon circumstances. Usually a severe pruning is necessary under normal conditions only after long intervals. Light pruning may be desirable every year or rather frequently, depending upon local orchard conditions.

Pruning stimulates the rate of growth of citrus fruits.

It has been demonstrated through extensive experimental and commercial citrus-orchard experience during the past 10 years that trees propagated from fruit-bearing budwood secured from superior performance-record parent trees of fruitful strains require but little pruning under normal conditions.

The use of a systematic individual-tree numbering system greatly facilitates and aids in pruning and related work.

In order to decide intelligently on pruning practices, growers should keep individual-tree records of production of a few pruned trees for comparison with the behavior of unpruned trees.

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